

Analysis of Covariance (ANCOVA)

ANOVA can be extended to include one or more continuous variables that predict the outcome (or dependent variable). Continuous variables such as these, that are not part of the main experimental manipulation but have an influence on the dependent variable, are known as *covariates* and they can be included in an ANOVA analysis. For example, in the Viagra example from Field (2009, Chapter 10), we might expect there to be other things that influence a person's libido other than Viagra. Some possible influences on libido might be the libido of the participant's sexual partner (after all 'it takes two to tango'!), other medication that suppresses libido (such as antidepressants), and fatigue. If these variables are measured, then it is possible to control for the influence they have on the dependent variable by including them in the model. What, in effect, happens is that we carry out a hierarchical regression in which our dependent variable is the outcome, and the covariate is entered in the first block. In a second block, our experimental manipulations are entered (in the form of what are called Dummy variables). So, we end up seeing what effect an independent variable has *after* the effect of the covariate. As such, we control for (or *partial out*) the effect of the covariate. Field (2009, Chapters 10 and 11) explains the similarity between ANOVA and regression and this is useful reading to understand how ANCOVA works.

The purpose of including covariates in ANOVA is two-fold:

1. *To reduce within-group error variance:* In ANOVA we assess the effect of an experiment by comparing the amount of variability in the data that the experiment can explain, against the variability that it cannot explain. If we can explain some of this 'unexplained' variance (SS_R) in terms of other variables (covariates), then we reduce the error variance, allowing us to more accurately assess the effect of the experimental manipulation (SS_M).
2. *Elimination of Confounds:* In any experiment, there may be unmeasured variables that confound the results (i.e. a variable that varies systematically with the experimental manipulation). If any variables are known to influence the dependent variable being measured, then ANCOVA is ideally suited to remove the bias of these variables. Once a possible confounding variable has been identified, it can be measured and entered into the analysis as a covariate.

Assumptions in ANCOVA

ANCOVA has the same assumptions as ANOVA except that there are two important additional considerations: (1) independence of the covariate and treatment effect, and (2) homogeneity of regression slopes. The first one basically means that the covariate should not be different across the groups in the analysis (in other words, if you did an ANOVA or *t*-test using the groups as the independent variable and the covariate as the outcome, this analysis should be non-significant). This assumption is quite involved so all I'll say is read my book chapter for more information, or read Miller and Chapman (2001).

When an ANCOVA is conducted we look at the overall relationship between the outcome (dependent variable) and the covariate: we fit a regression line to the entire data set, ignoring to which group a person belongs. In fitting this overall model we, therefore, assume that this overall relationship is true for all groups of participants. For example, if there's a positive relationship between the covariate and the outcome in one group, we assume that there is a positive relationship in all of the other groups too. If, however, the relationship between the outcome (dependent variable) and covariate differs across the groups then the overall regression model is inaccurate (it does not represent all of the groups). This assumption is very important and is called the assumption of *homogeneity of regression slopes*. The best way to think of this assumption is to imagine plotting a scatterplot for each experimental condition with the covariate on one axis and the outcome on the other. If you then calculated, and drew, the regression line for each of these scatterplots you should find that the regression lines look more or less the same (i.e. the values of *b* in each group should be equal). We will have a look at an example of this assumption and how to test it later.

ANCOVA on SPSS/PASW

Imagine that the researcher who conducted the Viagra study in Field (2009) suddenly realized that the libido of the participants' sexual partners would effect that participant's own libido (especially because the measure of libido was behavioural). Therefore, the researcher repeated the study on a different set of participants, but this time took a

measure of the partner's libido. The partner's libido was measured in terms of how often they tried to initiate sexual contact.

Entering Data

The data for this example are in Table 1, which shows the participant's libido and their partner's libido. The mean libido (and *SD* in brackets) of the participants' libido scores are in Table 2.



- Covariates are entered into the SPSS/PASW data editor in a new column (each covariate should have its own column).
- Covariates can be added to any of the different ANOVAs we have covered on this course!
 - When a covariate is added the analysis is called analysis of covariance (so, for example, you could have a two-way repeated measures Analysis of Covariance, or a three way mixed ANCOVA).

In essence, the data should be laid out in the Data Editor as they are Table 1. Without the covariate, the design is simply a one-way independent design, so we would enter these data using a coding variable for the independent variable, and scores on the dependent variable will go in a different column. All that changes is that we have an extra column for the covariate scores.

Table 1: Data from ViagraCov.sav


| Dose | Participant's Libido | Partner's Libido |
|-----------|----------------------|------------------|
| Placebo | 3 | 4 |
| | 2 | 1 |
| | 5 | 5 |
| | 2 | 1 |
| | 2 | 2 |
| | 2 | 2 |
| | 7 | 7 |
| | 2 | 4 |
| | 4 | 5 |
| Low Dose | 7 | 5 |
| | 5 | 3 |
| | 3 | 1 |
| | 4 | 2 |
| | 4 | 2 |
| | 7 | 6 |
| | 5 | 4 |
| | 4 | 2 |
| High Dose | 9 | 1 |
| | 2 | 3 |
| | 6 | 5 |
| | 3 | 4 |
| | 4 | 3 |
| | 4 | 3 |
| | 4 | 2 |
| | 6 | 0 |
| | 4 | 1 |
| | 6 | 3 |
| | 2 | 0 |
| | 8 | 1 |
| | 5 | 0 |

So, create a coding variable called **dose** and use the *Labels* option to define value labels (e.g. 1 = placebo, 2 = low dose, 3 = high dose). There were nine participants in the placebo condition, so you need to enter 9 values of 1 into this column (so that the first 9 rows contain the value 1), followed by eight values of 2 to represent the people in the low dose group, and followed by thirteen values of 3 to represent the people in the high dose group. At this point, you should have one column with 30 rows of data entered. Next, create a second variable called **libido** and enter the 30 scores that correspond to the participant's libido. Finally, create a third variable called **partner**, use the *Labels* option to give this variable a more descriptive title of 'partner's libido'. Then, enter the 30 scores that correspond to the partner's libido.

Table 2: Means (and standard deviations) from **ViagraCovariate.sav**

| Dose | Participant's Libido | Partner's Libido |
|-----------|----------------------|------------------|
| Placebo | 3.22 (1.79) | 3.44 (2.07) |
| Low Dose | 4.88 (1.46) | 3.12 (1.73) |
| High Dose | 4.85 (2.12) | 2.00 (1.63) |

Main Analysis

Most of the *General Linear Model* (GLM) procedures in SPSS/PASW contain the facility to include one or more covariates. For designs that don't involve repeated measures it is easiest to conduct ANCOVA via the GLM *Univariate* procedure. To access the main dialog box select **Analyze** → **General Linear Model** → **Univariate...** (see Figure 1). The main dialog box is similar to that for one-way ANOVA, except that there is a space to specify covariates. Select **Libido** and drag this variable to the box labelled *Dependent Variable* or click on . Select **Dose** and drag it to the box labelled *Fixed Factor(s)* and then select **Partner_Libido** and drag it to the box labelled *Covariate(s)*.

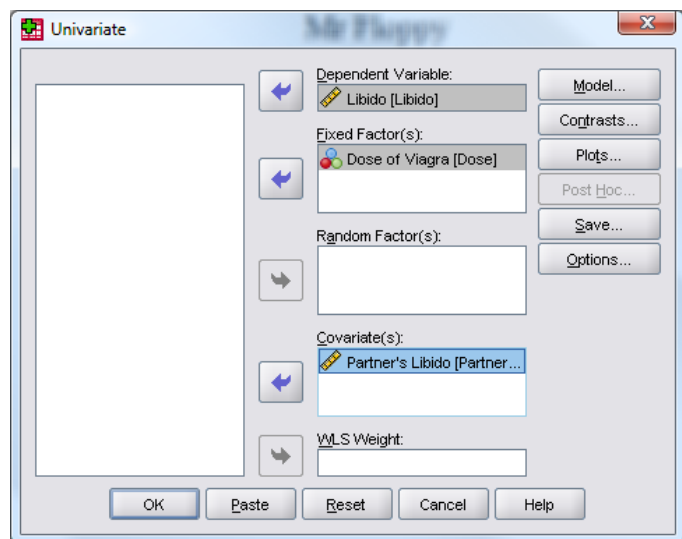



Figure 1: Main dialog box for GLM univariate

Contrasts and Other Options

There are various dialog boxes that can be accessed from the main dialog box. The first thing to notice is that if a covariate is selected, the post hoc tests are disabled (you cannot access this dialog box). Post hoc tests are not designed for situations in which a covariate is specified, however, some comparisons can still be done using contrasts.

Click on **Contrasts...** to access the *contrasts* dialog box. This dialog box is different to the one we met for ANOVA in that you cannot enter codes to specify particular contrasts. Instead, you can specify one of several standard contrasts. These standard contrasts were listed in my book. In this example, there was a placebo control condition (coded as the first group), so a sensible set of contrasts would be simple contrasts comparing each experimental group with the control. To select a type of contrast click on  to access a drop-down list of possible contrasts. Select a type of contrast (in this case *Simple*) from this list and the list will automatically disappear. For simple contrasts you have the option of specifying a reference category (which is the category against which all other groups are compared). By default the reference category is the last

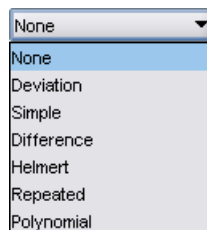


Figure 2: Options for standard contrasts in GLM univariate

category: because in this case the control group was the first category (assuming that you coded placebo as 1) we need to change this option by selecting **First**. When you have selected a new contrast option, you must click on **Change** to register this change. The final dialog box should look like Figure 2. Click on **Continue** to return to the main dialog box.

Another way to get *post hoc* tests is by clicking on **Options...** to access the *options* dialog box (see Figure 3). To specify *post hoc* tests, select the independent variable (in this case **Dose**) from the box labelled *Estimated Marginal Means: Factor(s) and Factor Interactions* and drag it to the box labelled *Display Means for* or click on **↓**. Once a variable has been transferred, the box labelled *Compare main effects* becomes active and you should select this option (☒ **Compare main effects**). If this option is selected, the box labelled *Confidence interval adjustment* becomes active and you can click on **LSD(none)** to see a choice of three adjustment levels. The default is to have no adjustment and simply perform a Tukey LSD *post hoc* test (this option is not recommended); the second is to ask for a Bonferroni correction (recommended); the final option is to have a **Sidak correction**. The Sidak correction is similar to the Bonferroni correction but is less conservative and so should be selected if you are concerned about the loss of power associated with Bonferroni corrected values. For this example use the Sidak correction (we will use Bonferroni later in the book). As well as producing *post hoc* tests for the **Dose** variable, placing **dose** in the *Display Means for* box will create a table of estimated marginal means for this variable. These means provide an estimate of the *adjusted* group means (i.e. the means adjusted for the effect of the covariate). When you have selected the options required, click on **Continue** to return to the main dialog box and click on **OK** to run the analysis.

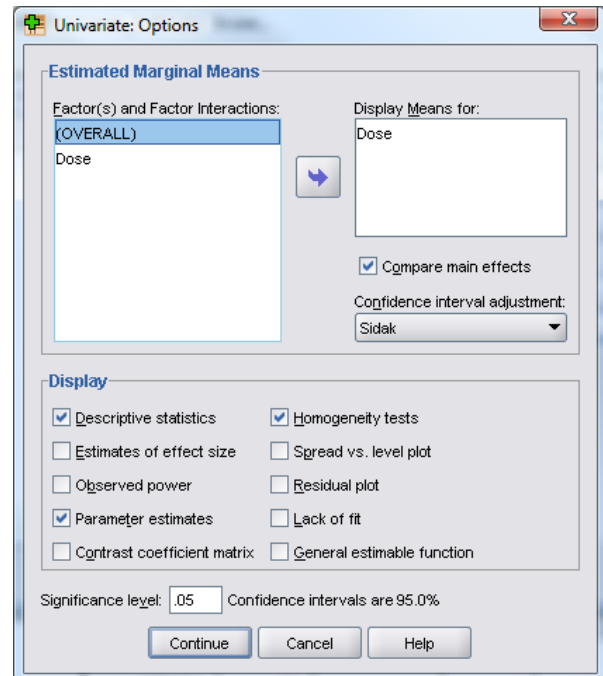


Figure 3: Options dialog box for GLM univariate

Output from ANCOVA

Main Analysis

SPSS/PASW Output 1 shows (for illustrative purposes) the ANOVA table for these data when the covariate is not included. It is clear from the significance value that there are no differences in libido between the three groups, therefore Viagra seems to have no significant effect on libido.

Tests of Between-Subjects Effects

Dependent Variable: Libido

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|-----------------|-------------------------|----|-------------|---------|------|
| Corrected Model | 16.844 ^a | 2 | 8.422 | 2.416 | .108 |
| Intercept | 535.184 | 1 | 535.184 | 153.522 | .000 |
| Dose | 16.844 | 2 | 8.422 | 2.416 | .108 |
| Error | 94.123 | 27 | 3.486 | | |
| Total | 683.000 | 30 | | | |
| Corrected Total | 110.967 | 29 | | | |

a. R Squared = .152 (Adjusted R Squared = .089)

SPSS/PASW Output 1

SPSS/PASW Output 2 shows the results of Levene's test when partner's libido is included in the model as a covariate. Levene's test is significant, indicating that the group variances are not equal (hence the assumption of homogeneity of variance has been violated). However, Levene's test is not necessarily the best way to judge whether variances are unequal enough to cause problems (see your handout from week 2 or Field, 2005 chapter 5). We saw in week 2 that a good double check is to look at the variance ratio¹.



→ As a bit of revision, calculate the variance ratio for these data before continuing (hint: you can compute the variances from values given in table 1!).

Levene's Test of Equality of Error Variances^a

Dependent Variable: Libido

| F | df1 | df2 | Sig. |
|-------|-----|-----|------|
| 4.618 | 2 | 27 | .019 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Partner_Libido + Dose

The variance ratio for these data is $4.49/2.13 = 2.11$. This value is greater than 2 indicating that our variances are probably heterogeneous! We saw last term that we could try to transform our data to correct this problem (have a go if you're feeling keen), but for the time being don't worry too much about the differences in variances.

SPSS/PASW Output 2

SPSS/PASW Output 3 shows the ANOVA table with the covariate included. Compare this to the summary table when the covariate was not included. The format of the ANOVA table is largely the same as without the covariate, except that there is an additional row of information about the covariate (**partner**). Looking first at the significance values, it is clear that the covariate significantly predicts the dependent variable, because the significance value is less than .05. Therefore, the person's libido is influenced by their partner's libido. What's more interesting is that when the effect of partner's libido is removed, the effect of Viagra becomes significant (p is .027 which is less than .05). The amount of variation accounted for by the model (SS_M) has increased to 31.92 units (corrected model) of which Viagra accounts for 25.19 units. Most important, the large amount of variation in libido that is accounted for by the covariate has meant that the unexplained variance (SS_R) has been reduced to 79.05 units. Notice that SS_T has not changed; all that has changed is how that total variation is explained.

This example illustrates how ANCOVA can help us to exert stricter experimental control by taking account of confounding variables to give us a 'purer' measure of effect of the experimental manipulation. Without taking account of the libido of the participants' partners we would have concluded that Viagra had no effect on libido, yet clearly it does. Looking back at the group means from Table 1 it seems pretty clear that the significant ANOVA reflects a difference between the placebo group and the two experimental groups (because the low and high dose group have very similar means whereas the placebo group have a lower mean). However, we need to check the contrasts to verify this conclusion.

¹ Reminder 1: the variance ratio is the largest variance divided by the smallest and should be less than about 2. You can get these variances by squaring the SDs in Table 1.

Tests of Between-Subjects Effects

Dependent Variable: Libido

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|-----------------|-------------------------|----|-------------|--------|------|
| Corrected Model | 31.920 ^a | 3 | 10.640 | 3.500 | .030 |
| Intercept | 76.069 | 1 | 76.069 | 25.020 | .000 |
| Partner_Libido | 15.076 | 1 | 15.076 | 4.959 | .035 |
| Dose | 25.185 | 2 | 12.593 | 4.142 | .027 |
| Error | 79.047 | 26 | 3.040 | | |
| Total | 683.000 | 30 | | | |
| Corrected Total | 110.967 | 29 | | | |

a. R Squared = .288 (Adjusted R Squared = .205)

SPSS/PASW Output 3



We can report the main effect of Dose in APA format as:

- ✓ There was a significant effect of Viagra on levels of libido after controlling for the effect of partner's libido, $F(2, 26) = 4.14, p < .05$.

Contrasts

Contrast Results (K Matrix)

| Dose of Viagra Simple Contrast ^a | | | | Depende... |
|---|--|--|--|------------|
| | | | | Libido |
| Level 2 vs. Level 1 | Contrast Estimate | | | 1.786 |
| | Hypothesized Value | | | 0 |
| | Difference (Estimate - Hypothesized) | | | 1.786 |
| | Std. Error | | | .849 |
| | Sig. | | | .045 |
| | 95% Confidence Interval for Difference | | | .040 |
| | | | | 3.532 |
| Level 3 vs. Level 1 | Contrast Estimate | | | 2.225 |
| | Hypothesized Value | | | 0 |
| | Difference (Estimate - Hypothesized) | | | 2.225 |
| | Std. Error | | | .803 |
| | Sig. | | | .010 |
| | 95% Confidence Interval for Difference | | | .575 |
| | | | | 3.875 |

a. Reference category = 1

Estimates

Dependent Variable: Libido

| Dose of Viagra | Mean | Std. Error | 95% Confidence Interval | |
|----------------|--------------------|------------|-------------------------|-------------|
| | | | Lower Bound | Upper Bound |
| Placebo | 2.926 ^a | .596 | 1.701 | 4.152 |
| Low Dose | 4.712 ^a | .621 | 3.436 | 5.988 |
| High Dose | 5.151 ^a | .503 | 4.118 | 6.184 |

a. Covariates appearing in the model are evaluated at the following values:
Partner's Libido = 2.73.

SPSS/PASW Output 4

SPSS/PASW Output 4 shows the result of the contrast analysis specified in Figure 2 and compares level 2 (low dose) against level 1 (placebo) as a first comparison, and level 3 (high dose) against level 1 (placebo) as a second comparison. These contrasts are consistent with what was specified: all groups are compared to the first group. The group differences are displayed: a difference value, standard error, significance value and 95% confidence interval. These results show that both the low-dose group (contrast 1, $p = .045$) and high-dose group (contrast 2, $p = .010$) had significantly different libidos than the placebo group.

These contrasts tell us that there were group differences, but to interpret them we need to know the means. We produced the means in Table 2 so surely we can just look at these values? Actually we can't because these group means have not been adjusted for the effect of the covariate. These original means tell us nothing about the group differences reflected by the significant ANCOVA. SPSS/PASW Output 4 gives the adjusted values of the group means and it is these values that should be used for interpretation (this is the main reason for selecting the *Display Means for*

option). The adjusted means (and our contrasts) show that levels of libido were significantly *higher* in the low- and high-dose groups compared to the placebo group.



We can report these contrasts in APA format as:

- ✓ Planned contrasts revealed that having a high, $p = .01$, and low, $p = .05$, dose of Viagra significantly increased libido compared to having a placebo.

Post Hoc Tests

SPSS/PASW Output 5 shows the results of the Sidak corrected *post hoc* comparisons that were requested as part of the *options* dialog box. The significant difference between the high dose and placebo group is confirmed. Note, however, that the difference between the low dose and placebo is no longer significant (can you think why?), and these tests also tell us that the high and low doses did not significantly differ ($p = .93$).

Pairwise Comparisons

Dependent Variable: Libido

| (I) Dose of Viagra | (J) Dose of Viagra | Mean Difference (I-J) | Std. Error | Sig. ^a | 95% Confidence Interval for Difference ^a | |
|--------------------|--------------------|-----------------------|------------|-------------------|---|-------------|
| | | | | | Lower Bound | Upper Bound |
| Placebo | Low Dose | -1.786 | .849 | .130 | -3.953 | .381 |
| | High Dose | -2.225* | .803 | .030 | -4.273 | -.177 |
| Low Dose | Placebo | 1.786 | .849 | .130 | -.381 | 3.953 |
| | High Dose | -.439 | .811 | .932 | -2.509 | 1.631 |
| High Dose | Placebo | 2.225* | .803 | .030 | .177 | 4.273 |
| | Low Dose | .439 | .811 | .932 | -1.631 | 2.509 |

Based on estimated marginal means

a. Adjustment for multiple comparisons: Sidak.

*. The mean difference is significant at the .05 level.

SPSS/PASW Output 5

Interpreting the Covariate

One way to discover the effect of the covariate is simply to draw a scatterplot of the covariate against the outcome. The resulting scatterplot for these data shows that the effect of covariate is that as partner's libido increases, so does the participant's libido (as shown by the slope of the regression line).

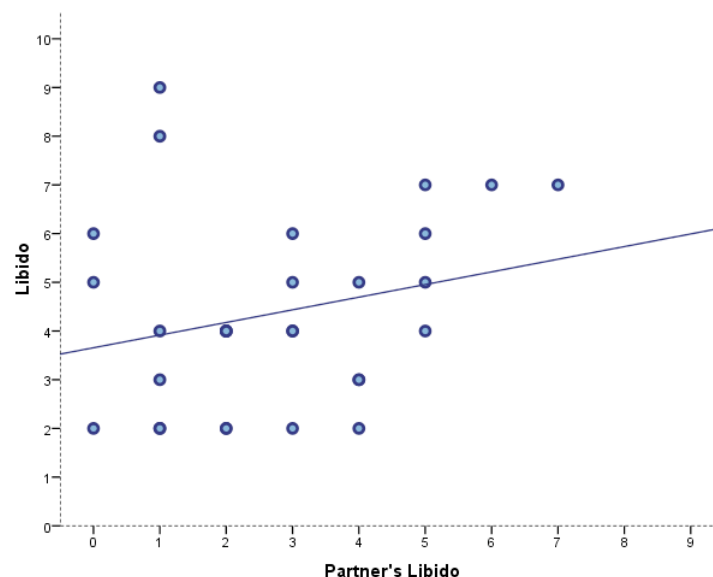


Figure 4: Scatterplot of participants' libido scores against those of their partner



We can report the effect of the covariate in APA format as:

- ✓ The covariate, partner's libido, was significantly related to the participant's libido, $F(1, 26) = 4.96, p < .05$.

Additional Assumptions in ANCOVA

When an ANCOVA is conducted we look at the overall relationship between the dependent variable and the covariate: we fit a regression line to the entire data set, ignoring to which group a participant belongs. In fitting this overall model we, therefore, assume that this overall relationship is true for all groups of participants. If, however, the relationship between the dependent variable and covariate is different in one of the groups then this overall regression model is inaccurate (it does not represent all of the groups). This assumption is very important and is called the **assumption of homogeneity of regression slopes**. The best way to think of this assumption is to imagine plotting a scatterplot for each experimental condition with the covariate on one axis and the dependent variable on the other. If you then calculated, and drew, the regression line for each of these scatterplots you should find that the regression lines look more or less the same.

Figure 5 shows scatterplots that display the relationship between partner's libido (the covariate) and the outcome (participant's libido) for each of the three experimental conditions (different colours and symbols). Each symbol represents the data from a particular participant, and the type of symbol tells us the group (circles = placebo, triangles = low dose, squares = high dose). The lines are the regression slopes for the particular group, they summarise the relationship between libido and partner's libido shown by the dots (blue = placebo group, green = low-dose group, red = high-dose group). It should be clear that there is a positive relationship (the regression line slopes upwards from left to right) between partner's libido and participant's libido in both the placebo and low-dose conditions. In fact, the slopes of the lines for these two groups (blue and green) are very similar, showing that the relationship between libido and partner's libido is very similar in these two groups. This situation is an example of homogeneity of regression slopes (the regression slopes in the two groups are similar). However, in the high-dose condition there appears to be no relationship at all between participant's libido and that of their partner (the squares are fairly randomly scattered and the regression line is very flat and shows a slightly negative relationship). The slope of this line is very different to the other two, and this difference gives us cause to doubt whether there is homogeneity of regression slopes (because the relationship between participant's libido and that of their partner is different in the high-dose group to the other two groups).

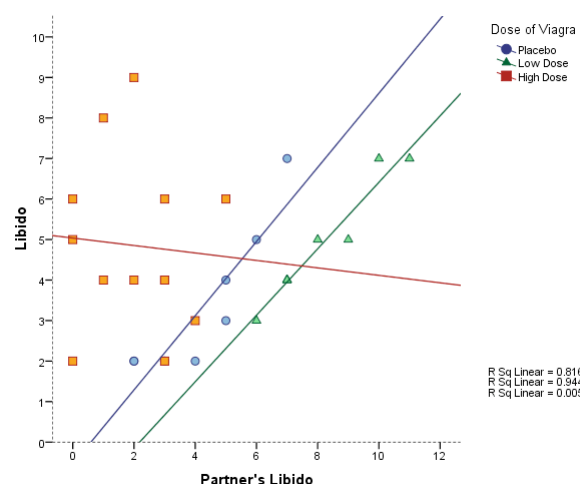


Figure 5: Scatterplot of Libido against Partner's libido for each of the experimental conditions

To test the assumption of homogeneity of regression slopes we need to rerun the ANCOVA but this time use a customized model. Access the main dialog box as before and place the variables in the same boxes as before (so the

finished box should look like Figure 1). To customize the model we need to access the model dialog box by clicking on **Model...**. To customize your model, select **Custom** to activate the dialog box (Figure 5). The variables specified in the main dialog box are listed on the left-hand side. To test the assumption of homogeneity of regression slopes, we need to specify a model that includes the interaction between the covariate and independent variable. Hence, to begin with you should select **Dose** and **Partner_Libido** (you can select both of them at the same time by holding down *Ctrl*). Then, click on the drop-down menu and change it to **Main effects**. Having selected this, click on **➔** to move the main effects of **Dose** and **Partner_Libido** to the box labelled **Model**. Next we need to specify the interaction term. To do this, select **Dose** and **Partner_Libido** simultaneously (by holding down the *Ctrl* key while you click on the two variables), then select **Interaction** in the drop-down list and click on **➔**. This action moves the interaction of **Dose** and **Partner_Libido** to the box labelled **Model**. The finished dialog box should look like Figure 6. Having specified our two main effects and the interaction term, click on **Continue** to return to the main dialog box and then click on **OK** to run the analysis.

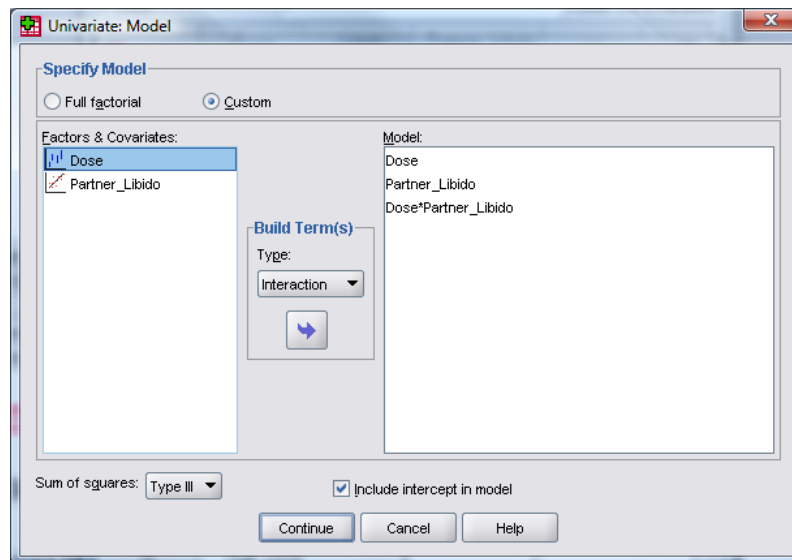


Figure 6: GLM univariate *model* dialog box

SPSS/PASW Output 5 shows the main summary table for the ANCOVA using only the interaction term. Look at the significance value of the covariate by dependent variable interaction (**dose*partner**), if this effect is significant then the assumption of homogeneity of regression slopes has been broken. The effect here is significant ($p < 0.05$); therefore the assumption is not tenable. Although this finding is not surprising given the pattern of relationships shown in Figure 4 it does raise concern about the main analysis. This example illustrates why it is important to test assumptions and not to just blindly accept the results of an analysis.

Tests of Between-Subjects Effects

| Dependent Variable: Libido | | | | | |
|----------------------------|-------------------------|----|-------------|--------|------|
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Corrected Model | 52.346 ^a | 5 | 10.469 | 4.286 | .006 |
| Intercept | 53.542 | 1 | 53.542 | 21.921 | .000 |
| Dose | 36.558 | 2 | 18.279 | 7.484 | .003 |
| Partner_Libido | 17.182 | 1 | 17.182 | 7.035 | .014 |
| Dose * Partner_Libido | 20.427 | 2 | 10.213 | 4.181 | .028 |
| Error | 58.621 | 24 | 2.443 | | |
| Total | 683.000 | 30 | | | |
| Corrected Total | 110.967 | 29 | | | |

a. R Squared = .472 (Adjusted R Squared = .362)

SPSS/PASW Output 6

Guided Example:

Stalking is a very disruptive and upsetting (for the person being stalked) experience in which someone (the stalker) constantly harasses or obsesses about another person. A psychologist, who'd had enough of being stalked by people,

decided to try two different therapies on different groups of stalkers (25 stalkers in each group—this variable is called **Group**). The first group of stalkers he gave what he termed cruel to be kind therapy. This therapy was based on punishment for stalking behaviours: every time the stalker followed him around, or sent him a letter, the psychologist attacked them with a cattle prod until they stopped their stalking behaviour. The second therapy was psychodynamic therapy, which was a recent development on Freud's psychodynamic therapy that acknowledges what a sham this kind of treatment is. The stalkers were hypnotised and regressed into their childhood, the therapist would also discuss their penis (unless it was a woman in which case they discussed their lack of penis), the penis of their father, their dog's penis, the penis of the cat down the road, and anyone else's penis that sprang to mind. At the end of therapy, the psychologist measured the number of hours in the week that the stalker spent stalking their prey (this variable is called **stalk2**). The therapist believed that the success of therapy might well depend on how bad the problem was to begin with, so before therapy the therapist measured the number of hours that the patient spent stalking as an indicator of how much of a stalker the person was (this variable is called **stalk1**). The data are in the file **Stalker.sav**, analyse the effect of therapy on stalking behaviour after therapy, controlling for the amount of stalking behaviour before therapy.

| Cruel to be Kind Therapy | | Psychodynamic Therapy | |
|--------------------------|------------------------|-----------------------|------------------------|
| Initial Stalking | Stalking After Therapy | Initial Stalking | Stalking After Therapy |
| 47 | 11 | 52 | 47 |
| 50 | 18 | 53 | 47 |
| 51 | 34 | 54 | 50 |
| 52 | 40 | 57 | 55 |
| 53 | 50 | 58 | 56 |
| 57 | 54 | 60 | 56 |
| 57 | 55 | 61 | 61 |
| 60 | 58 | 61 | 61 |
| 63 | 59 | 62 | 61 |
| 66 | 60 | 65 | 61 |
| 68 | 61 | 66 | 62 |
| 72 | 61 | 66 | 62 |
| 72 | 62 | 66 | 62 |
| 73 | 63 | 71 | 64 |
| 75 | 64 | 71 | 64 |
| 77 | 65 | 72 | 64 |
| 79 | 65 | 75 | 70 |
| 85 | 78 | 77 | 74 |
| 62 | 55 | 80 | 78 |
| 71 | 63 | 87 | 78 |
| 53 | 52 | 75 | 62 |
| 64 | 80 | 57 | 71 |
| 79 | 35 | 59 | 55 |
| 75 | 70 | 46 | 46 |
| 60 | 61 | 89 | 79 |



- Enter the data into SPSS/PASW. (Hint: The data should not be entered as they are in the table above).
- Save the data onto a disk in a file called **stalker.sav**.
- Conduct the appropriate analysis to see whether the two therapies had a significant effect on stalking behaviour when controlling for the person's general tendency to stalk.

What is/are the independent variable(s) and how many levels do they have?

Your Answer:

What is the dependent variable?

Your Answer:

What is the covariate?

Your Answer:

What analysis have you performed?

Your Answer:

Has the assumption of homogeneity of variance been met? (Quote relevant statistics in APA format).

Your Answer:

Report the effect of 'therapy' in APA format. Is this effect significant and how would you interpret it?

Your Answer:

Report the effect of 'initial stalking' in APA format. Is this effect significant and how would you interpret it?

Your Answer:

Some answers to this question can be found on the companion website of my book.

Unguided Example

A marketing manager for a certain well-known drinks manufacturer was interested in the therapeutic benefit of certain soft drinks for curing hangovers. He took 15 people out on the town one night and got them drunk. The next morning as they awoke, dehydrated and feeling as though they'd licked a camel's sandy feet clean with their tongue, he gave 5 of them water to drink, 5 of them Lucozade, and the remaining five a leading brand of cola (this variable is called **drink**). He then measured how well they felt (on a scale from 0 = I feel like death to 10 = I feel really full of beans and healthy) two hours later (this variable is called **well**). He wanted to know which drink produced the greatest level of wellness. However, he realised it was important to control for how **drunk** the person got the night before, and so he's measured this on a scale of 0 = as sober as a nun to 10 = flapping about like a haddock out of water on the floor in a puddle of their own vomit.

| Water | | Lucozade | | Cola | |
|-------|-------|----------|-------|------|-------|
| Well | Drunk | Well | Drunk | Well | Drunk |
| 5 | 5 | 5 | 6 | 5 | 2 |
| 5 | 3 | 4 | 6 | 6 | 3 |
| 6 | 2 | 6 | 4 | 6 | 2 |
| 6 | 1 | 8 | 2 | 6 | 3 |
| 3 | 7 | 6 | 3 | 6 | 2 |



- Enter the data into SPSS/PASW. (Hint: The data should not be entered as they are in the table above).
- Save the data onto a disk in a file called **HangoverCure.sav**.
- Conduct the appropriate analysis to see whether the drinks differ in their ability to control hangovers when controlling for how much was drunk the night before.

Some answers to this question can be found on the companion website of my book.

Multiple Choice Questions



Complete the multiple choice questions for **Chapter 11** on the companion website to Field (2009): <http://www.uk.sagepub.com/field3e/MCQ.htm>. If you get any wrong, re-read this handout (or Field, 2009, Chapter 11) and do them again until you get them all correct.

References

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology*, 110, 40-48

This handout contains material from:

Field, A. P. (2009). *Discovering statistics using SPSS: and sex and drugs and rock 'n' roll (3rd Edition)*. London: Sage.

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